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Case Studies using the WipFrag Image Analysis System

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Synopsis

Photoanalysis systems have become practical and useful tools for measuring the performance of explosives in breaking rock, determining the validity of blast models and examining the efficiency of crushers and grinding circuits. This emerging technology has provided many opportunities to diagnose problems, increase productivity, reduce costs and optimize the performance of these activities by examining the cause and effect relationships that occur in these operations. This paper will attempt to summarize a few of these applications that have been documented since the last FRAGBLAST Conference.

1. Introduction

The WipFrag fragmentation sizing system (Figure 1) has been in widespread use for many years now[1,2,3]. It is being used in the explosives, mining, and materials handling industries for the purpose of evaluating the efficiency of the comminution process, whether by blasting, crushing, grinding, or inadvertently by materials handling processes.

At the last FRAGBLAST Conference the benefits of optical gradations methodologies were demonstrated. Gradation measurements can be automated, eliminating the subjectivity of manual measurements. Because of extremely low per unit costs, many more measurements can be made, resulting in lower sampling errors[4,5]. Interruption of production processes is not required, and results are available in a very short time, allowing timely adjustments to production methods. In the case of large blocks or large volumes of rock, screening is just too prohibitive, and optical methods are the only alternative.

Optical methods have come under criticism for proported lack of accuracy, inability to measure fines, and other various perceived deficiencies[6]. In part these criticisms are justified, and indeed, under some conditions optical methods achieve very poor results. Further research has been conducted to quantify the errors associated with these systems[7]. By far the most significant source of error is sampling. This is in some cases because of poor judgement in where images are taken, in others because of the inability to get a representative sample by looking at only the surface of a pile of rocks, or simply because of the sheer variability inherent with measuring fragmentation. Sampling errors can be decreased by systematic sampling strategies, and by analyzing a larger number of samples. In many cases the best way to do this is to use on-line analysis, where the material is imaged as it passes by on a conveyor belt[8].

However there are many applications where results have justified the use of optical systems. Published applications using the WipFrag system include the following.

2. Applications

2.1 Selbaie Mine - Joutel, Quebec, Canada

Selbaie Mine, Joutel, Quebec, Canada, were able to optimize their blast performance, monitor energy consumption, loading rates, payloads of haulage trucks, secondary blasting costs, and maintenance costs as a function of fragment size[9].

Selbaie used photographic fragmentation analysis in the mid-nineties as a basis for evaluating explosive product performance, pattern optimization and as important criteria relating to other mining costs.

Data obtained revealed the effect of fragmentation on:

- Energy consumption to crush a ton of material.
- Loading rates of haulage trucks.

- Loaded weight of haulage trucks.
- Secondary blasting costs.
- Maintenance costs.
- Characterization of rock in various areas of the pit.

While these relationships were strongly suspected by many, the full extent and cost of some had been severely underestimated. Now that they could readily measure fragmentation, the true costs of mineral processing were better understood and managed.

2.2 INCO Coleman Mine - Sudbury, Ontario, Canada

INCO's Coleman Mine, Sudbury, Ontario, Canada, was able to expand their blasting pattern by 40%, with cost saving of up to 80%, while actually improving the degree of fragmentation[9].

INCO conducted a study program throughout the summer of 1994. A large block of ore was mined and detailed records kept regarding blast patterns and fragmentation. The original blast pattern (5ft.x10ft.) yielded a characteristic size (Xc) of .617m. and there was oversize generated that required additional blasting. The WipFrag histogram revealed both excessive oversize and fines suggesting that perhaps the pattern was "too tight". The pattern was expanded to 6ft.x10ft. and fragmentation improved to Xc=.509m but still contained oversize.

The pattern was further expanded to 7ft.x10ft. and this time the characteristic size dropped to .318m and oversize appeared eliminated.

INCO ultimately realized a 40% pattern expansion, fragmentation nearly twice as good as originally experienced and in addition oversize was all but eliminated.

This program would have been impossible to evaluate without "WipFrag" (Figure 2. The good statistical base (a large number of photographic images analyzed throughout the mining of this ore block) reinforced their confidence in this method.

An unseen benefit of pattern expansion could be in the area of fines reduction. Increasingly, mining companies are realizing that fines generation can be a significant problem. Fines are difficult to handle, oxidize rapidly, and tend to plug ore passes. The oxidized nature of this material can also affect the recovery process. Since most fines are generated by localized crushing, due to severe pressure around the bore hole, it follows that pattern expansion with subsequent reduction in boreholes for given volume of rock should significantly reduce fines generation[10].

2.3 Highland Valley Copper - Logan Lake, British Columbia, Canada

Highland Valley Copper, Logan Lake, British Columbia, Canada, have been able to correlate their mill tonnage with the feed size and hardness tracking, paving the way to greater production by optimizing feed size[11].

Highland Valley Copper implemented a system of measuring run-of-mine (ROM) ore properties and monitoring their effect on both mine and mill performance. These properties were principally ore hardness and size.

Using the latest technology available, ore properties are tracked through the in-pit crushing, conveying and stockpile network to the mill feed using the mine dispatch system and some simple models (Figure 3).

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The result is a continuous update on the ore hardness going to all five grinding lines. This gives both operators and process-control systems the opportunity to shift targets and/or change operating conditions to suit the ore properties.

Ore size distributions, from the muck pile to the mill, are measured using video cameras and the WipFrag image analysis software. These measurements provide feedback on the control of blast fragmentation as well as optimize mill throughput. At this location, four of the five grinding lines are affected, either positively or negatively, by segregation in the stockpiles. WipFrag analysis of the two autogenous mills has shown a consistent difference in the two feed sizes. The difference also changes over time as the stockpile composition and volume varies.

These segregation effects are minimized through the manipulation of stockpile feeders and WipFrag results.

Highland Valley Copper is in a unique situation of knowing the amenability of the ore they are treating through systems put in place to measure and monitor the ore properties in real-time. This information can then be used by the mine and mill engineers to improve the productivity and efficiency of their operations.

By quantifying the effects of fragmentation on mill production, a cost benefit analysis can be performed to determine the optimum degree of breakage in the mine. In other words, at what point does spending more money in the mine for better size reduction not have an increased benefit to Highland Valley Copper as a whole?

It is possible, using a monitoring tool like WipFrag, to reduce the feed imbalance by changing the feeder ratios or how the stockpile is drawn down by the two lines. Experience at HVC has shown that, not only does every mill prefer a different feed size, but identical mills can be particular as well!

2.4 Bartley and Trousselle, - Ogdensburg, New York, USA

Bartley and Trousselle were able to show a direct relationship between accurate detonator timing and improved fragmentation[12].

In tests conducted at Benchmark Materials Quarry in August 25-September 5, 1997 at Ogdensburg, NY Bartley and Trousselle concluded that "High accuracy detonators produced better fragmentation and reduced vibration levels." Blast fragmentation size and uniformity was measured using WipFrag and a significant increase in overall blast performance was noted using programmable digital detonators.

2.5 Lafarge Canada Inc., - Exshaw, Alberta, Canada

Lafarge Exshaw Finer Fragmentation Study (Figure 4) was able to conclude that improved fragmentation reduced mechanical down time, improved crusher throughput and decreased power consumption savings in the crusher circuit[13].

Elliott, Ethier and Levaque concluded that[13]:

- Subdrill from previous shots was responsible for much of the oversize generated in later blasts.
- Cross drill bits produced less hole deviation than ballistic-type button bits.
- A new blast design with 102mm blastholes could produce finer, more uniform fragmentation.
- This better fragmentation resulted in savings in mechanical down time (easier digging and improved tire life on loaders).

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- Better fragmentation improved crusher throughput by 16% and power consumption savings by 30%
- The new blast design eliminated complaints from neighbors by lowering vibration levels.
- The lower charge weight per hole caused less damage to the final walls and improved safety.

2.6 Barkley and Carter

Barkley and Carter evaluated the accuracy of optical sizing methods and realized the significance of increased fragmentation on throughput and power consumption[14].

They concluded that blast optimization had been hampered in the past due to a lack of inexpensive, reliable sizing measurements. A new optical system (WipFrag) was tested and found to be (if carefully applied) a usable method of fragmentation assessment allowing decision making for blast modeling, equipment selection, mining methods and economic planning. They showed Crusher Performance vs. Fragmentation relationships and discussed the sampling frequency required for various types of muck pile variability.

2.7 Chiappetta, Treleaven and Smith

Chiappetta, Treleaven and Smith in their work on the expansion of the Panama Canal used WipFrag to evaluate fragmentation results and stemming consistency[15].

The Panama Canal expansion work was reported to be one of the most challenging jobs of the decade in terms of complex geology, water saturation levels, constant marine traffic and tight schedules. State of the art instrumentation was essential in monitoring conditions as well as tracking the progress of design changes and blast results.

3. Conclusions

More uses and “secrets” are being discovered daily as industry accepts and becomes familiar with photoanalysis as a tool for measuring sizes. Significant cost savings are being realized in processes that were thought to be “understood” but lacked an easy way to measure improvement as it relates to cost of production.

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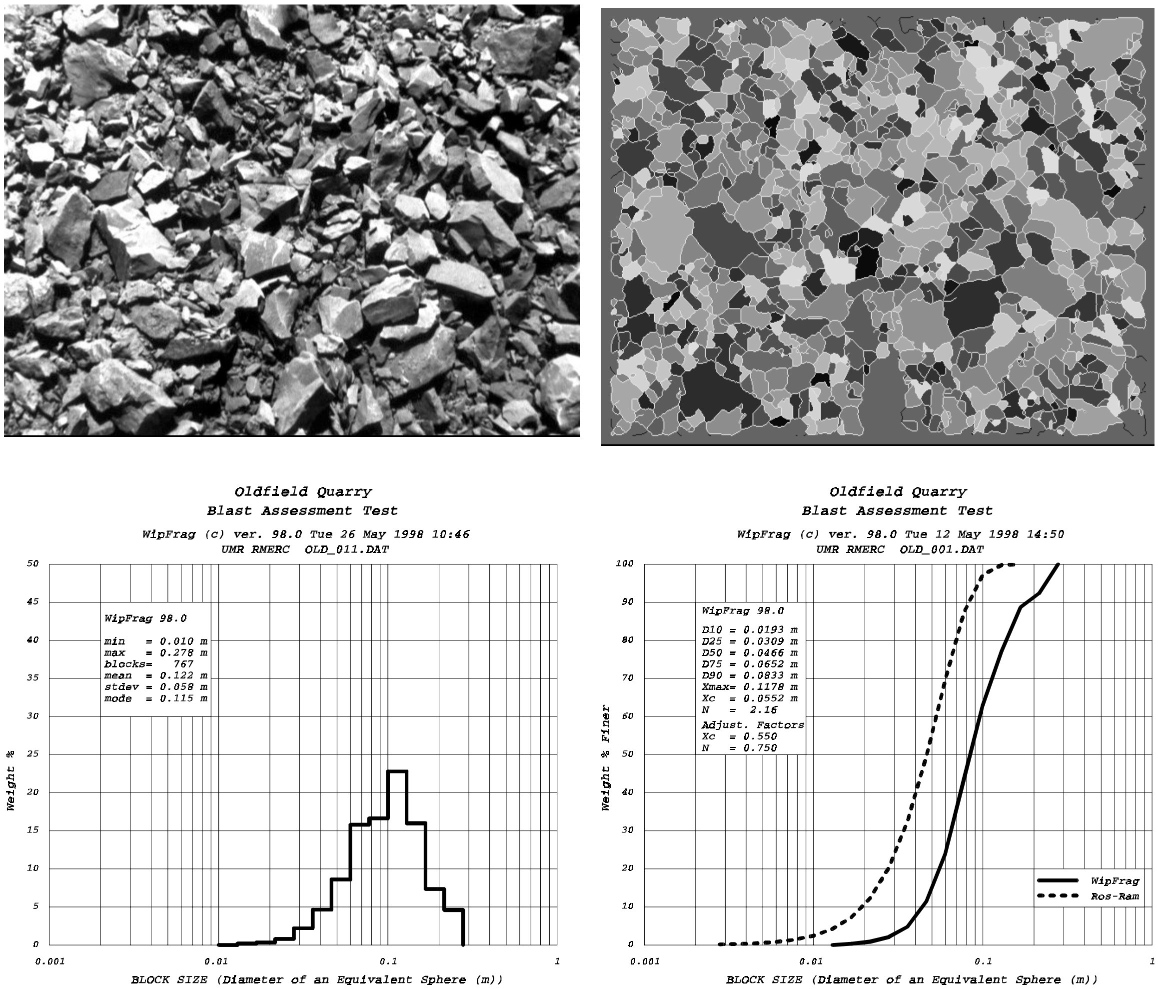

Figure 1. Top left: Typical image of rock fragmentation. Top right: Computer generated block outlines. Bottom right: Measured Histogram. Bottom left: Cumulative weight percent distribution, with calibrated curve (dashed line).

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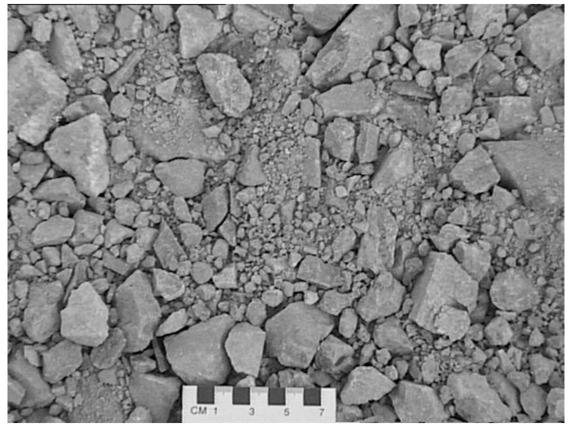

Figure 2. INCO Study. Left: Loading explosives. Right: Fines analysis.

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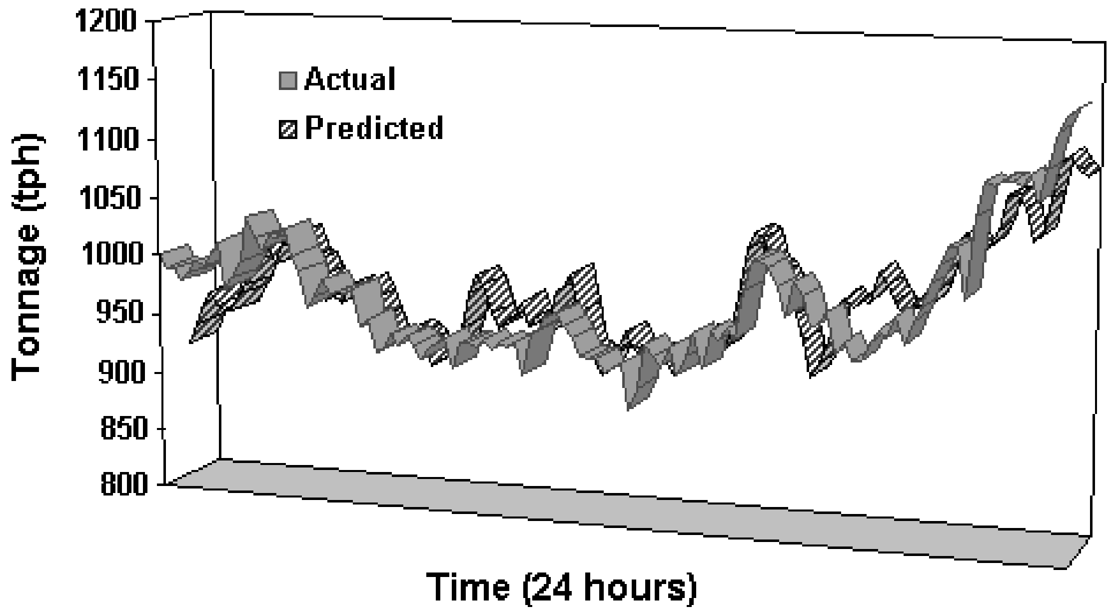

Figure 3. Comparison of predicted (modeled) vs. actual mill throughput based on input parameters of size and hardness[11].

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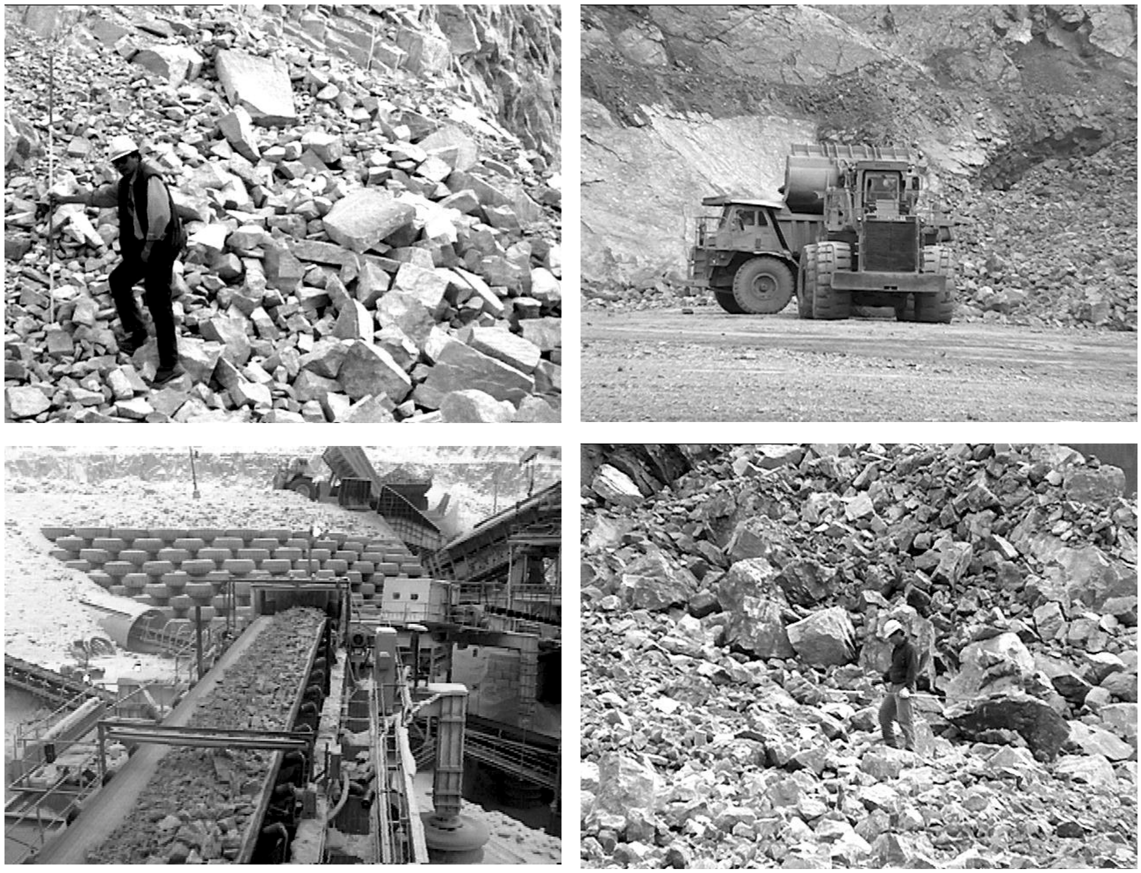

Figure 4. Fragmentation analysis at Lafarge, Exshaw Alberta.